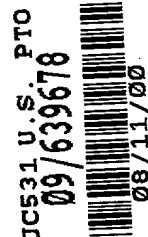


Assistant Commissioner For Patents  
Washington, D.C. 20231



08-14-00  
Case Docket No.: CORE-57



Sir:

Transmitted herewith for filing is the patent application of:

Inventor: Daryoosh Vakhshoori et al.  
For: METHOD FOR MODULATING AN OPTICALLY PUMPED, TUNABLE VERTICAL CAVITY SURFACE EMITTING LASER (VCSEL)

Enclosed are:

- ☒ 3 sheets of drawings.
- ☐ An assignment of the invention to: \_\_\_\_\_
- ☐ A verified statement to establish small entity status.
- ☐ \_\_\_\_\_

The filing fee has been calculated as shown below:

For:	No. Filed	No. Extra	Small Entity		Large Entity	
			Rate	Fee	Rate	Fee
Basic Fee				\$0.00		\$690.00
Total Claims	2 - 20	0	x \$ 9.00	0.00	x \$18.00	0.00
Ind. Claims	2 - 3	0	x \$39.00	0.00	x \$78.00	0.00
Mult. Claims			+ \$130.00		+ \$260.00	

Total \$690.00

- ☐ Please charge my Deposit Account No. 16-0221 to cover the filing fee and assignment recording fee. A duplicate copy of this sheet is enclosed.
- ☒ A check in the amount of \$690.00 to cover the filing fee ~~(and assignment recording fee)~~ is enclosed.
- ☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 16-0221. A duplicate copy of this sheet is enclosed.
  - ☒ Any additional filing fees required under 37 CFR 1.16.
  - ☒ Any patent application processing fees under 37 CFR 1.17.
- ☒ The Commissioner is hereby authorized to charge payment of the following fees during the pendency of this application or credit any overpayment to Deposit Account No. 16-0221. A duplicate copy of this sheet is enclosed.
  - ☒ Any patent application processing fees under 37 CFR 1.17.
  - ☐ The issue fee set in 37 CFR 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR 1.311(b).
  - ☒ Any filing fees under 37 CFR 1.16 for presentation of extra claims.

Respectfully submitted,

*James A. Sheridan* 8/11/2000  
Pandiscio & Pandiscio  
470 Totten Pond Road  
Waltham, Massachusetts 02451-1914  
Tel. (781) 290-0060

MB/CORE57.FEE

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Daryoosh Vakhshoori et al.  
 Title: METHOD FOR MODULATING AN OPTICALLY  
 PUMPED, TUNABLE VERTICAL CAVITY  
 SURFACE EMITTING LASER (VCSEL)

Attorney's Docket No.: CORE-57

Date: August 11, 2000

BOX PATENT APPLICATION  
 Assistant Commissioner For Patents  
 Washington, D.C. 20231

Sir:

FILING OF PATENT APPLICATION UNDER 37 CFR 1.10

The attached application is being filed under the  
 provisions of 37 CFR 1.10.

Applicant's attorney is also submitting the requisite  
 fee as calculated on the attached transmittal letter.

"EXPRESS MAIL" MAILING LABEL NUMBER EK830344253US Respectfully submitted,

DATE OF DEPOSIT AUGUST 11, 2000

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED  
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JAMES A. SHERIDAN 8/11/2000  
 (PERSON MAILING)

James A. Sheridan 8/11/2000  
 (SIGNATURE)

MB/CORE57.FIL

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APPLICATION  
FOR  
UNITED STATES LETTERS PATENT

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PATENT APPLICATION

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SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that Daryoosh Vakhshoori of 10 Rogers Street, Apt. 205, Cambridge, Massachusetts 02142 and Parviz Tayebati of 65 East India Road, Apt. 2C, Boston, MA 02110 have invented certain improvements in METHOD FOR MODULATING AN OPTICALLY PUMPED, TUNABLE VERTICAL CAVITY SURFACE EMITTING LASER (VCSEL) of which the following description is a specification.

MB/CORE57.CVR

CORE-57

METHOD FOR MODULATING AN OPTICALLY PUMPED, TUNABLE  
VERTICAL CAVITY SURFACE EMITTING LASER (VCSEL)

Reference To Pending Prior Patent Application

This patent application claims benefit of pending prior U.S. Provisional Patent Application Serial No. 60/148,629, filed 08/12/99 by Daryoosh Vakhshoori and Parviz Tayebati for MODULATION METHODS OF OPTICALLY PUMPED TUNABLE VERTICAL CAVITY SURFACE EMITTING LASERS, which patent application is hereby incorporated herein by reference.

Field Of The Invention

This invention relates to photonic devices in general, and more particularly to tunable lasers.

Background Of The Invention

In pending prior U.S. Patent Application Serial No. 09/105,399, filed 06/26/98 by Parviz Tayebati et al. for MICROELECTROMECHANICALLY TUNABLE, CONFOCAL, VERTICAL CAVITY SURFACE EMITTING LASER AND FABRY-PEROT

FILTER, and in pending prior U.S. Patent Application Serial No. 09/543,318, filed 04/05/00 by Peidong Wang et al. for SINGLE MODE OPERATION OF MICROMECHANICALLY TUNABLE, HALF-SYMMETRIC, VERTICAL CAVITY SURFACE EMITTING LASERS, which patent applications are hereby incorporated herein by reference, there are disclosed tunable Fabry-Perot filters and tunable vertical cavity surface emitting lasers (VCSEL's).

More particularly, and looking now at Fig. 1, there is shown a tunable vertical cavity surface emitting laser (VCSEL) 5 formed in accordance with the aforementioned U.S. Patent Applications Serial Nos. 09/105,399 and 09/543,318. VCSEL 5 generally comprises a substrate 10, a bottom mirror 20 mounted to the top of substrate 10, a gain medium (or "active region") 23 mounted to the top of bottom mirror 20, a bottom electrode 15 mounted to the top of gain medium 23, a thin support 25 atop bottom electrode 15, a top electrode 30 fixed to the underside of thin support 25, a reinforcer 35 fixed to the outside perimeter of thin support 25, and a confocal top mirror 40 set atop

thin support 25, with an air cavity 45 being formed between bottom mirror 20 and top mirror 40.

As a result of this construction, when active region 23 is appropriately stimulated, e.g., by optical pumping or electrical current, lasing can be established within air cavity 45, between top mirror 40 and bottom mirror 20. Furthermore, by applying an appropriate voltage across top electrode 30 and bottom electrode 15, the position of top mirror 40 can be changed relative to bottom mirror 20, whereby to change the length of the laser's resonant cavity, and hence tune VCSEL 5.

The present invention is directed to VCSEL's which are constructed so as to have their active region stimulated by optical pumping.

#### Objects Of The Invention

The primary object of the present invention is to provide a novel method for modulating the output of an optically pumped, tunable VCSEL.

Another object of the present invention is to provide a novel method for modulating the output of an optically pumped, tunable VCSEL by modulating the pump laser.

And another object of the present invention is to provide a novel method for modulating the output of an optically pumped, tunable VCSEL by modulating a voltage applied across the active region.

#### Summary Of The Invention

These and other objects are addressed by the present invention.

In one form of the invention, there is provided a method for modulating the output of an optically pumped, tunable VCSEL, wherein the method comprises the steps of: (1) optically pumping the VCSEL with a pump laser so as to cause the VCSEL to generate an output; and (2) modulating the output light power of the pump laser so as to modulate the carrier population in the VCSEL's active region whereby to modulate the output of the VCSEL.

In another form of the invention, there is provided a method for modulating the output of an optically pumped, tunable VCSEL, wherein the method comprises the steps of: (1) optically pumping the VCSEL with a pump laser so as to cause the VCSEL to generate an output; and (2) applying a voltage across the active region so as to alter the optical power circulating in the VCSEL's cavity, whereby to increase or decrease the output power of the VCSEL.

#### Brief Description Of The Drawings

These and other objects and features of the present invention will be more fully disclosed or rendered obvious by the following detailed description of the preferred embodiments of the invention, which is to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

Fig. 1 is a schematic side view of a tunable VCSEL;



Fig. 2 is a schematic diagram showing the output of an optically pumped, tunable VCSEL being modulated by modulating the pump laser; and

Fig. 3 is a schematic diagram showing the output of an optically pumped, tunable VCSEL being modulated by modulating a voltage applied across the VCSEL's active region.

#### Detailed Description Of The Preferred Embodiments

The present invention provides two ways for modulating the output of an optically pumped, tunable vertical cavity surface emitting laser (VCSEL).

In the first approach, the pump laser is directly modulated in the manner shown in Fig. 2. More particularly, the pump laser 100 is imaged on the active region of VCSEL 5. The pump laser can be of the 980 nm or 1400-1500 nm variety, and is typically of edge-emitting geometry. As the output light power of the pump laser 100 is modulated, the carrier population in the VCSEL's active region is also

modulated. This in turn results in modulation of the output of VCSEL 5.

In the second approach, the P-N junction of the VCSEL's active region is either forward or reverse biased to modulate the output of VCSEL 5. This is schematically illustrated in Fig. 3. More particularly, in this approach, the pump laser 100 is operated in CW mode and biases the VCSEL's output to a DC level. Then the application of the voltage  $V_2 - V_1$  across the active region will add to, or subtract from, the optical power circulating in the VCSEL's cavity, resulting in an increase, or decrease, in the output power of VCSEL 5.

#### Modifications

It is to be understood that the present invention is by no means limited to the particular constructions and method steps disclosed above and/or shown in the drawings, but also comprises any modifications or equivalents within the scope of the claims.

What Is Claimed Is:

1. A method for modulating the output of an optically pumped, tunable VCSEL, wherein said method comprises the steps of:

(1) optically pumping the VCSEL with a pump laser so as to cause the VCSEL to generate an output; and

(2) modulating the output light power of the pump laser so as to modulate the carrier population in the VCSEL's active region, whereby to modulate the output of the VCSEL.

2. A method for modulating the output of an optically pumped, tunable VCSEL, wherein said method comprises the steps of:

(1) optically pumping the VCSEL with a pump laser so as to cause the VCSEL to generate an output; and

(2) applying a voltage across the VCSEL's active region so as to alter the optical power circulating in

the VCSEL's cavity, whereby to increase or decrease the output power of the VCSEL.

Abstract

A method for modulating the output of an optically pumped, tunable VCSEL. Two approaches are disclosed. In a first approach, the output of the VCSEL is modulated by modulating the pump laser. In a second approach, the output of the VCSEL is modulated by modulating a voltage applied across the active region.

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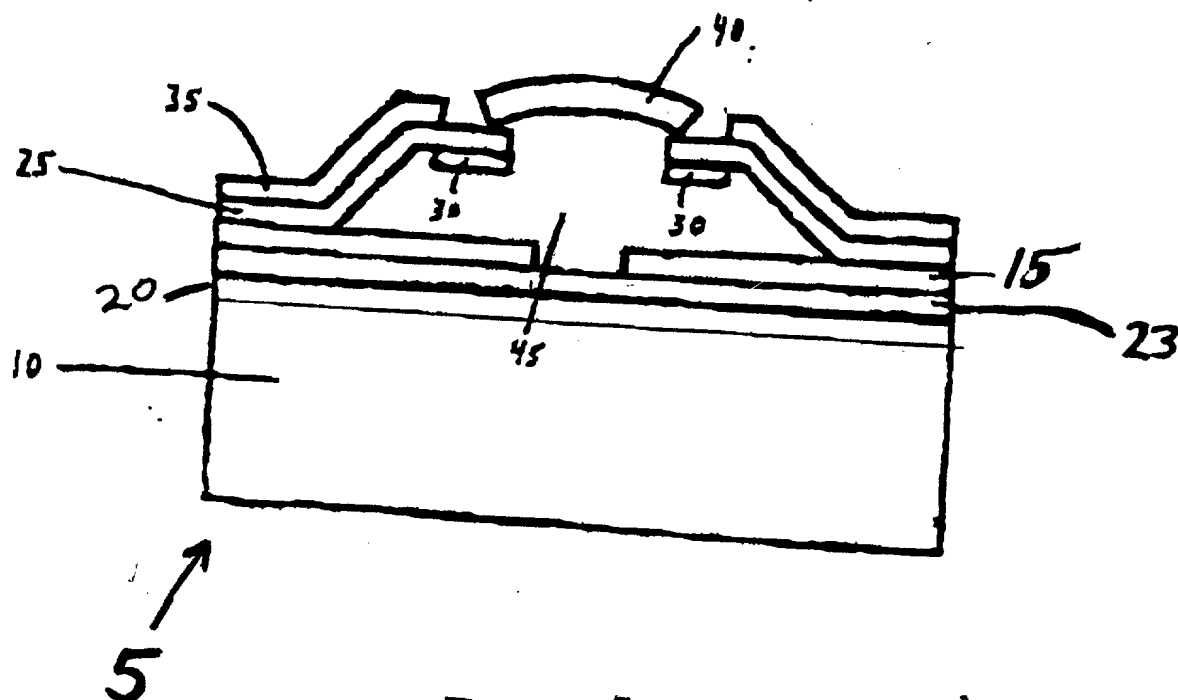


FIG. 1

001-000-00000000

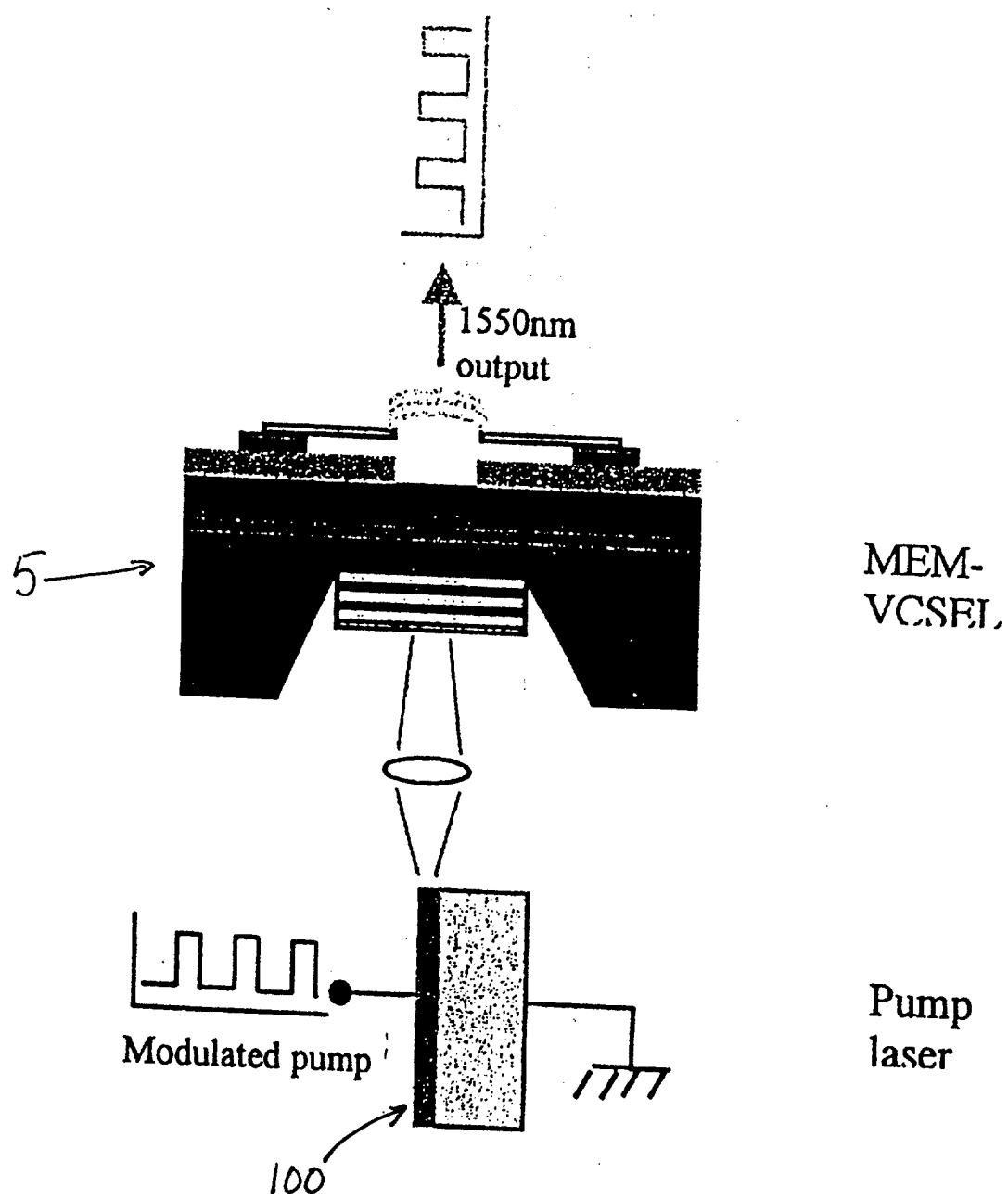


Fig. 2

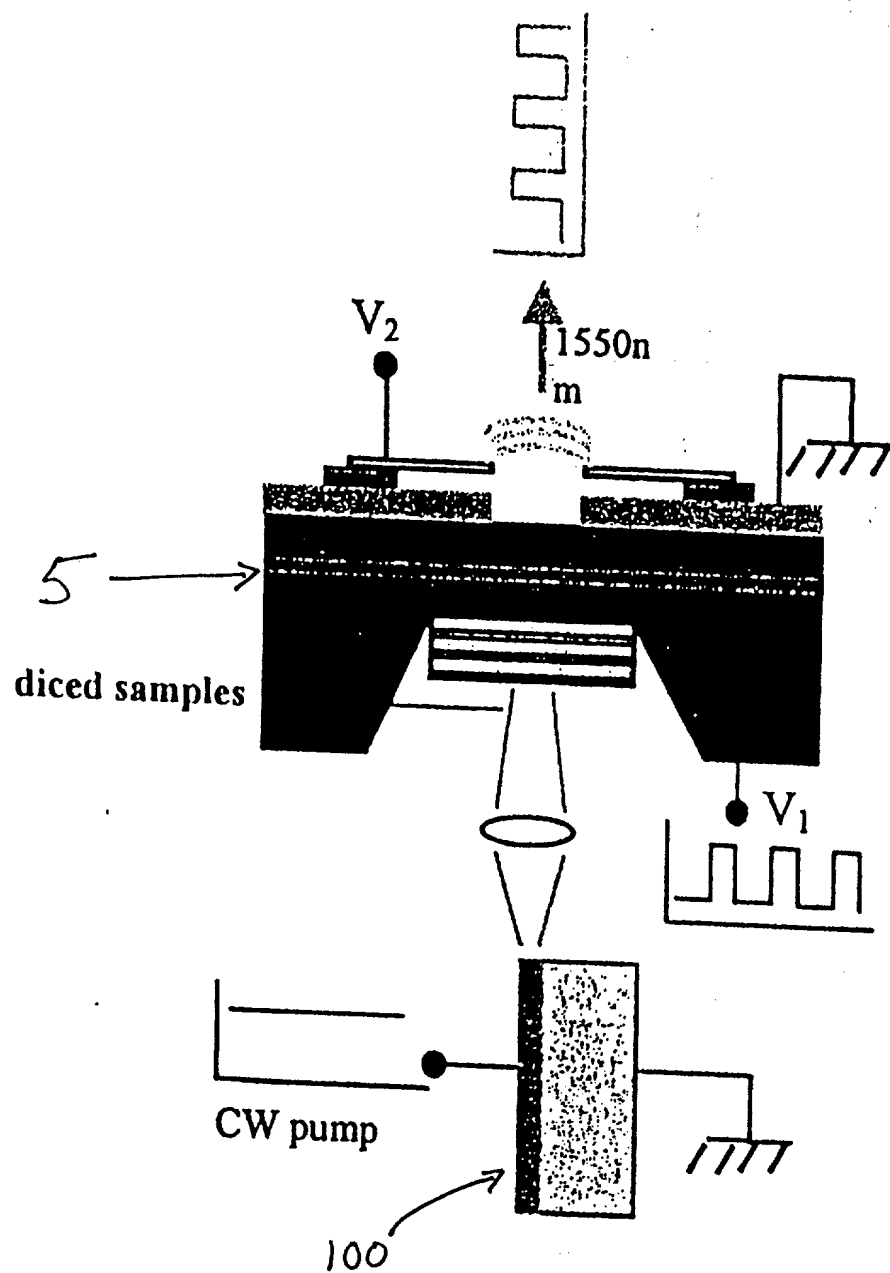


Fig. 3



DECLARATION AND POWER OF ATTORNEY

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled "METHOD FOR MODULATING AN OPTICALLY PUMPED, TUNABLE VERTICAL CAVITY SURFACE EMITTING LASER (VCSEL)", the specification of which is filed herewith, and is identified by Attorney's Docket No. CORE-57.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I hereby claim priority benefits under Title 35, United States Code, Section 119(e), of U.S. Provisional Patent Application Serial No. 60/148,629, filed

08/12/99 for MODULATION METHODS OF OPTICALLY PUMPED  
TUNABLE VERTICAL CAVITY SURFACE EMITTING LASERS.

I hereby appoint Pandiscio & Pandiscio, a firm composed of Nicholas A. Pandiscio, Registration No. 17293, Mark J. Pandiscio, Registration No. 30883, Scott R. Foster, Registration No. 20570, and James A. Sheridan, Registration No. 43,114, or any of them, of 470 Totten Pond Road, Waltham, Massachusetts 02451-1914, (Telephone No. 781-290-0060), my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Boston, MA 02110  
Post office address: same  
Citizenship: United States

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CORE-57